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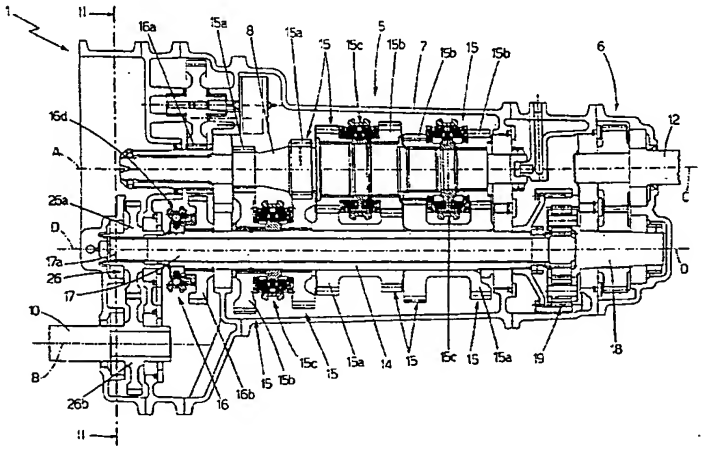
(54) Title: FOUR-WHEEL-DRIVE VEHICLE TRANSMISSION



(57) Abstract: A four-wheel-drive vehicle transmission (1) having a drive torque input shaft (8) rotated by the vehicle engine (2) about a first axis of rotation (A); a front output shaft (10) connected to the front axle (3) of the vehicle; a rear output shaft (12) connected to the rear axle (4) of the vehicle; an auxiliary tubular shaft (14) mounted alongside the input shaft (8) to rotate about a second axis of rotation (D) parallel to the first axis of rotation (A); a number of groups of gears (15, 16) for selectively connecting the auxiliary tubular shaft (14) mechanically to the input shaft (8); a first countershaft (17) mounted for rotation about the second axis of rotation (D) inside the auxiliary tubular shaft (14); a second countershaft (18) mounted for rotation about the second axis of rotation (D) opposite the first countershaft (17); a planetary gear train (19) for mechanically connecting the auxiliary tubular shaft (14) to the first (17) and second (18) countershaft; and a first (25) and a second (26) cascade gear set for mechanically connecting the second countershaft (18) to the rear output shaft (12), and the first countershaft (17) to the front output shaft respectively (10).

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FOUR-WHEEL-DRIVE VEHICLE TRANSMISSION

TECHNICAL FIELD

The present invention relates to a four-wheel-drive vehicle transmission.

More specifically, the present invention relates to a transmission for high-performance, four-wheel-drive cars, to which the following description refers purely by way of example.

BACKGROUND ART

As is known, in some conditions, high-performance cars have great difficulty discharging the power from the engine to the road. In recent years, therefore, a number of major car manufacturers have begun marketing high-performance car models with four-wheel drives.

Besides effectively solving the problem of discharging the power from the engine to the road, such a solution also provides for greatly improving control, road-holding in poor-grip conditions, and therefore intrinsic safety of the vehicle.

Unfortunately, currently marketed four-wheel-drive car transmissions have the major drawback of being

extremely heavy and bulky, thus creating serious design problems in terms of location within the vehicle and weight distribution over the two vehicle axles. The structure of currently marketed transmissions, in fact, is derived directly from that normally employed in off-road vehicles, in which the weight and bulk of the transmission are considered secondary to strength and simplifying construction.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide a four-wheel-drive vehicle transmission, which is more compact and lightweight than those currently used, and which is suitable for use in high-performance cars.

According to the present invention, there is provided a four-wheel-drive vehicle transmission comprising a drive torque input shaft rotated by the vehicle engine about a first axis of rotation; a front output shaft connected to the front axle of the vehicle; and a rear output shaft connected to the rear axle of the vehicle; said transmission being characterized by also comprising an auxiliary tubular shaft mounted alongside said input shaft to rotate about a second axis of rotation parallel to said first axis of rotation; a number of groups of gears for selectively connecting the auxiliary tubular shaft mechanically to said input shaft; a first countershaft mounted for rotation about said second axis of rotation inside said auxiliary tubular shaft; a second countershaft mounted for rotation about

said second axis of rotation opposite said first countershaft; a planetary gear train for mechanically connecting said auxiliary tubular shaft to the first and second countershaft; and a first and a second cascade gear set for mechanically connecting the first countershaft to the rear output shaft, and the second countershaft to the front output shaft respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a schematic plan view of a four-wheel-drive vehicle equipped with a transmission in accordance with the teachings of the present invention;

Figure 2 shows a section, with parts removed for clarity, of the Figure 1 transmission;

Figure 3 shows a larger-scale view of a detail in Figure 2;

Figure 4 shows a section, with parts removed for clarity, of the Figure 2 and 3 transmission along line IV-IV;

Figure 5 shows a section, with parts removed for clarity, of the Figure 2 transmission along line II-II.

BEST MODE FOR CARRYING OUT THE INVENTION

Number 1 in Figure 1 indicates as a whole a four-wheel-drive vehicle gear transmission, which may be used to particular advantage in high-performance, permanent four-wheel-drive cars with a longitudinal engine.

Cars of the above type comprise an internal combustion engine 2 housed longitudinally inside the vehicle, i.e. parallel to the longitudinal axis of the vehicle; a front axle 3 for transferring the drive torque from engine 2 to the front wheels of the vehicle; and a rear axle 4 for transferring the drive torque from engine 2 to the rear wheels of the vehicle.

With reference to Figures 1 and 2, transmission 1 connects engine 2 mechanically to front axle 3 and rear axle 4 of the vehicle, and comprises a transmission case 5 and a central differential 6 integrated inside one rigid outer shell 7 designed to minimize the overall size of the transmission.

More specifically, transmission 1 comprises a drive torque input shaft 8 connected directly to engine 2 by a known clutch assembly 9; a front output shaft 10 connected to front axle 3 of the vehicle by a first propeller shaft 11; and a rear output shaft 12 connected to rear axle 4 of the vehicle by a second propeller shaft 13.

With reference to Figures 1 and 2, input shaft 8 is mounted to rotate about an axis A of rotation preferably, though not necessarily, parallel to the longitudinal axis of the vehicle; and front output shaft 10 and rear output shaft 12 are mounted to rotate about respective axes B and C of rotation parallel to axis A.

In the example shown, input shaft 8 and rear output shaft 12 are aligned opposite each other, so that axes A

and C coincide.

With reference to Figure 2, inside rigid outer shell 7, transmission 1 comprises an auxiliary tubular shaft 14 extending alongside and parallel to input shaft 8; and a number of pairs of gears 15 for selectively connecting auxiliary tubular shaft 14 mechanically to input shaft 8, so that input shaft 8 rotates auxiliary tubular shaft 14 about an axis D of rotation at an angular speed depending on the reduction ratio of each pair of gears 15.

In the example shown, each pair of gears 15 comprises a primary gear 15a fitted permanently to input shaft 8 or auxiliary tubular shaft 14; a secondary gear 15b fitted in freely rotating manner to the other of the two shafts and meshing with primary gear 15a; and a synchronizing unit 15c fitted to input shaft 8 or auxiliary tubular shaft 14, alongside secondary gear 15b, and for selectively making secondary gear 15b angularly integral with the shaft to which it is fitted, so as to transfer the drive torque from one shaft to the other.

More specifically, in the example shown, transmission 1 comprises six forward pairs of gears 15 arranged as follows: four consecutive pairs of gears 15 are fitted to input shaft 8 and auxiliary tubular shaft 14, so that synchronizing units 15c are located on input shaft 8; and the other two pairs of gears 15 are fitted to input shaft 8 and auxiliary tubular shaft 14, so that synchronizing units 15c are located on auxiliary tubular shaft 14.

It should be pointed out that, besides halving the number of synchronizing units 15c required to operate secondary gears 15b - each synchronizing unit 15c is, in fact, located between and provides for connecting two adjacent secondary gears 15b to the shaft - the above arrangement also minimizes the axial length of input shaft 8 and auxiliary tubular shaft 14. The axial width of synchronizing units 15c, in fact, affects the overall axial length of both shafts, which is reduced to the absolute minimum by distributing synchronizing units 15c on both input shaft 8 and auxiliary tubular shaft 14.

With reference to Figures 2 and 5, in the example shown, transmission 1 also comprises a cascade gear set 16 for selectively connecting auxiliary tubular shaft 14 mechanically to input shaft 8, so that input shaft 8 rotates auxiliary tubular shaft 14 about axis D in the opposite direction to that produced by connecting auxiliary tubular shaft 14 to input shaft 8 by means of pairs of gears 15, thus inverting the traveling direction of the vehicle (reverse).

More specifically, cascade gear set 16 comprises a primary gear 16a fitted permanently to input shaft 8; a secondary gear 16b fitted in freely rotating manner to auxiliary tubular shaft 14; an intermediate gear 16c mounted for rotation alongside primary gear 16a and secondary gear 16b, so as to mesh simultaneously with both; and a synchronizing unit 16d fitted to auxiliary tubular shaft 14, alongside secondary gear 16b, and for

selectively making secondary gear 16b angularly integral with the shaft to which it is fitted, so as to transfer the drive torque from one shaft to the other.

Synchronizing units 15c and 16d are well known automotive mechanical components which require no further description; nor is any description required of the known manner in which the units are operated to engage and disengage gears by forks in transmission case 5.

With reference to Figures 2, 3 and 4, transmission 1 also comprises a first countershaft 17 mounted for rotation about axis D inside auxiliary tubular shaft 14; a second countershaft 18 mounted for rotation about axis D opposite countershaft 17; and a planetary gear train 19 located between countershafts 17 and 18, and for connecting countershafts 17 and 18 mechanically to auxiliary tubular shaft 14, so that auxiliary tubular shaft 14 rotates countershafts 17 and 18 simultaneously.

More specifically, countershaft 17 is longer than, is mounted for rotation inside, and projects at both axial ends outwards of, auxiliary tubular shaft 14. In the example shown, one axial end of countershaft 17 - hereinafter indicated 17a - projects outwards of auxiliary tubular shaft 14, and is located alongside a corresponding axial end 10a of front output shaft 10; and the other end of countershaft 17 - hereinafter indicated 17b - is fitted with a pinion 20 defining the sun gear of planetary gear train 19.

The end of auxiliary tubular shaft 14 facing pinion

20 is fitted with a circular flange in turn fitted integrally with a ring gear 21 with inward-facing teeth. Ring gear 21 is positioned facing and coaxial with pinion 20, and defines the outer ring gear of planetary gear train 19.

Countershaft 18 is located alongside one end of rear output shaft 12, and its axial end directly facing pinion 20 is fitted with a circular flange 22 on which are mounted for rotation three pairs of gears 23.

With reference to Figures 3 and 4, each pair of gears 23 comprises an inner gear 23a meshing with pinion 20; and an outer gear 23b meshing simultaneously with inner gear 23a and ring gear 21. Inner gears 23a and outer gears 23b are mounted to rotate freely on spindles extending from circular flange 22, parallel to axis D, and define the planet gears of planetary gear train 19, the planet carrier of which is obviously defined by circular flange 22.

With reference to Figures 2, 3 and 5, transmission 1 also comprises a first cascade gear set 25 for connecting countershaft 18 mechanically to rear output shaft 12; and a second cascade gear set 26 for connecting countershaft 17 mechanically to front output shaft 10. In the example shown, cascade gear set 25 comprises two mutually meshing gears 25a and 25b fitted to countershaft 18 and to rear output shaft 12 respectively; and cascade gear set 26 comprises two mutually meshing gears 26a and 26b fitted to axial end 17a of countershaft 17 and to front output

shaft 10 respectively.

Operation of gear transmission 1 as described and illustrated herein is self-explanatory.

The advantages of gear transmission 1 are obvious: the high degree of component integration provides for obtaining a structure which is extremely compact and lightweight, but at the same time capable of transferring exceptionally high drive torques from engine 2 to front and rear axles 3 and 4.

Input shaft 8 and rear output shaft 12 being coaxial, transmission 1 can be located inside the vehicle closer to the road surface, thus lowering the center of gravity of the car, with obvious advantages in terms of stability and control.

Clearly, changes may be made to transmission 1 as described and illustrated herein without, however, departing from the scope of the present invention.

CLAIMS

1) A four-wheel-drive vehicle transmission (1) comprising a drive torque input shaft (8) rotated by the vehicle engine (2) about a first axis of rotation (A); a front output shaft (10) connected to the front axle (3) of the vehicle; and a rear output shaft (12) connected to the rear axle (4) of the vehicle; said transmission (1) being characterized by also comprising an auxiliary tubular shaft (14) mounted alongside said input shaft (8) to rotate about a second axis of rotation (D) parallel to said first axis of rotation (A); a number of groups of gears (15, 16) for selectively connecting the auxiliary tubular shaft (14) mechanically to said input shaft (8); a first countershaft (17) mounted for rotation about said second axis of rotation (D) inside said auxiliary tubular shaft (14); a second countershaft (18) mounted for rotation about said second axis of rotation (D) opposite said first countershaft (17); a planetary gear train (19) for mechanically connecting said auxiliary tubular shaft (14) to the first (17) and second (18) countershaft; and a first (25) and a second (26) cascade gear set for mechanically connecting the first countershaft (18) to the rear output shaft (12), and the second countershaft (17) to the front output shaft respectively (10).

2) A transmission as claimed in Claim 1, characterized in that the front output shaft (10) and the rear output shaft (12) are mounted for rotation

respectively about a third (B) and a fourth (C) axis of rotation, which are parallel to said first axis of rotation (A).

3) A transmission as claimed in Claim 2, characterized in that said input shaft (8) and said rear output shaft (12) are coaxial.

4) A transmission as claimed in Claim 3, characterized in that said planetary gear train (19) is located between said first (17) and said second (18) countershaft, and comprises a pinion (20) fitted to the end of the first countershaft (17); a ring gear (21) carried by said auxiliary tubular shaft (14) so as to be coaxial with said pinion (10); and a number of planet gears (23) mounted for rotation on a planet carrier flange (22) fitted to said second countershaft (18); said planet gears (23) meshing with said pinion (20) and/or said ring gear (21).

5) A transmission as claimed in Claim 4, characterized in that said number of planet gears (23) comprise a number of pairs of gears (23); each said pair of gears (23) comprising an inner gear (23a) meshing with said pinion (20), and an outer gear (23b) meshing simultaneously with the inner gear (23a) and said ring gear (21).

6) A transmission as claimed in any one of the foregoing Claims, characterized in that said number of groups of gears (15, 16) for selectively connecting the input shaft (8) mechanically to the auxiliary tubular

shaft (14) comprise a number of pairs of gears (15) for selectively connecting the auxiliary tubular shaft (14) mechanically to the input shaft (8); each pair of gears (15) comprising a primary gear (15a) fitted permanently to the input shaft (8) or to the auxiliary tubular shaft (14), a secondary gear (15b) fitted in freely rotating manner to the other of the two shafts and meshing with the primary gear (15a), and a synchronizing unit (15c) fitted to the input shaft (8) or to the auxiliary tubular shaft (14), alongside the secondary gear (15b), and for selectively making the secondary gear (15b) angularly integral with the shaft to which it is fitted, so as to transfer drive torque from one shaft to the other.

7) A transmission as claimed in Claim 6, characterized in that the synchronizing units (15c) corresponding to the various pairs of gears (15) are located partly on said input shaft (8) and partly on said auxiliary tubular shaft (14).

8) A transmission as claimed in any one of the foregoing Claims, characterized in that said first cascade gear set (25) comprises two gears (25a, 25b) meshing with each other and fitted to the countershaft (18) and rear output shaft (12) respectively.

9) A transmission as claimed in any one of the foregoing Claims, characterized in that said second cascade gear set (26) comprises two gears (26a, 26b) meshing with each other and fitted to the countershaft (17) and front output shaft (10) respectively.

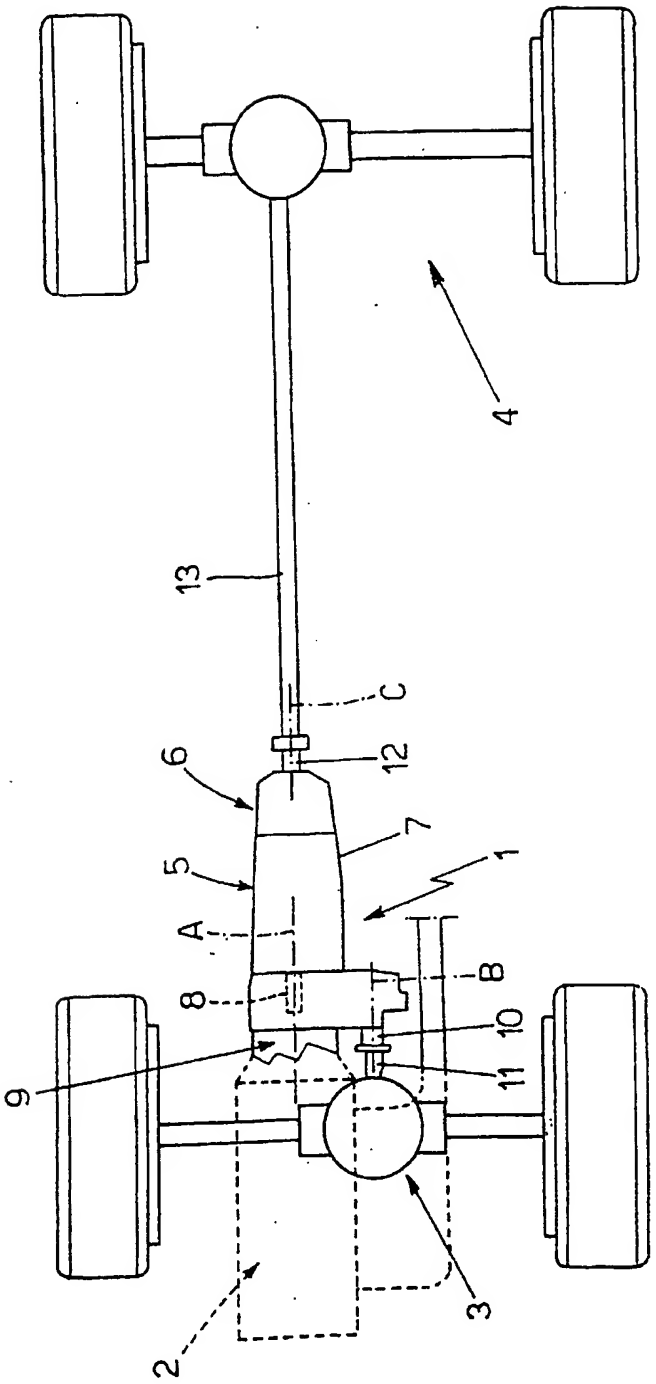
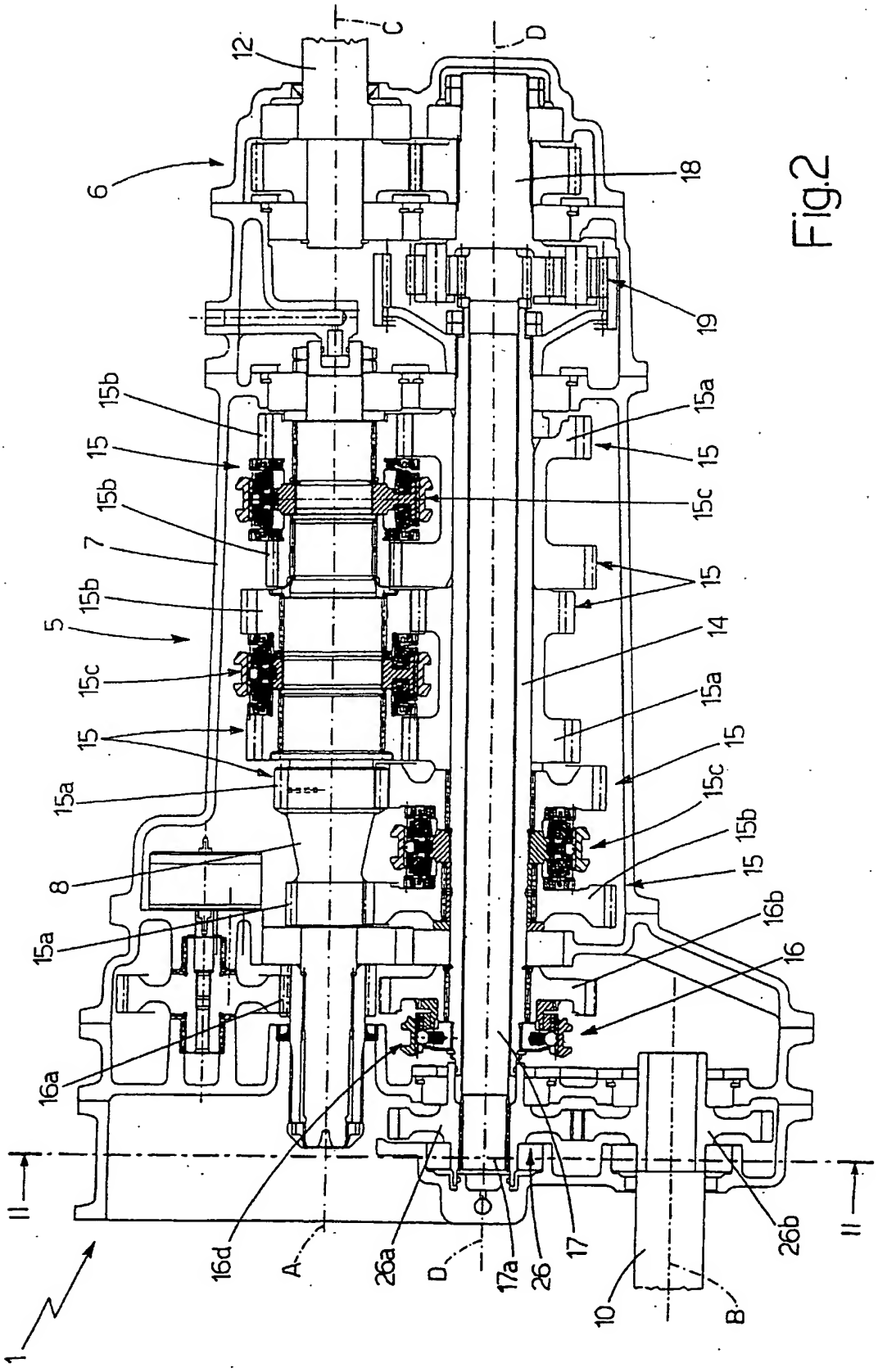


Fig.1


12
C
D
6
18
19
15b
15
15a
15c
7
5
14
8
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16
16a
16d
A
26a
D
17a
26
17
10
B
26b
II
II
1

Fig.2

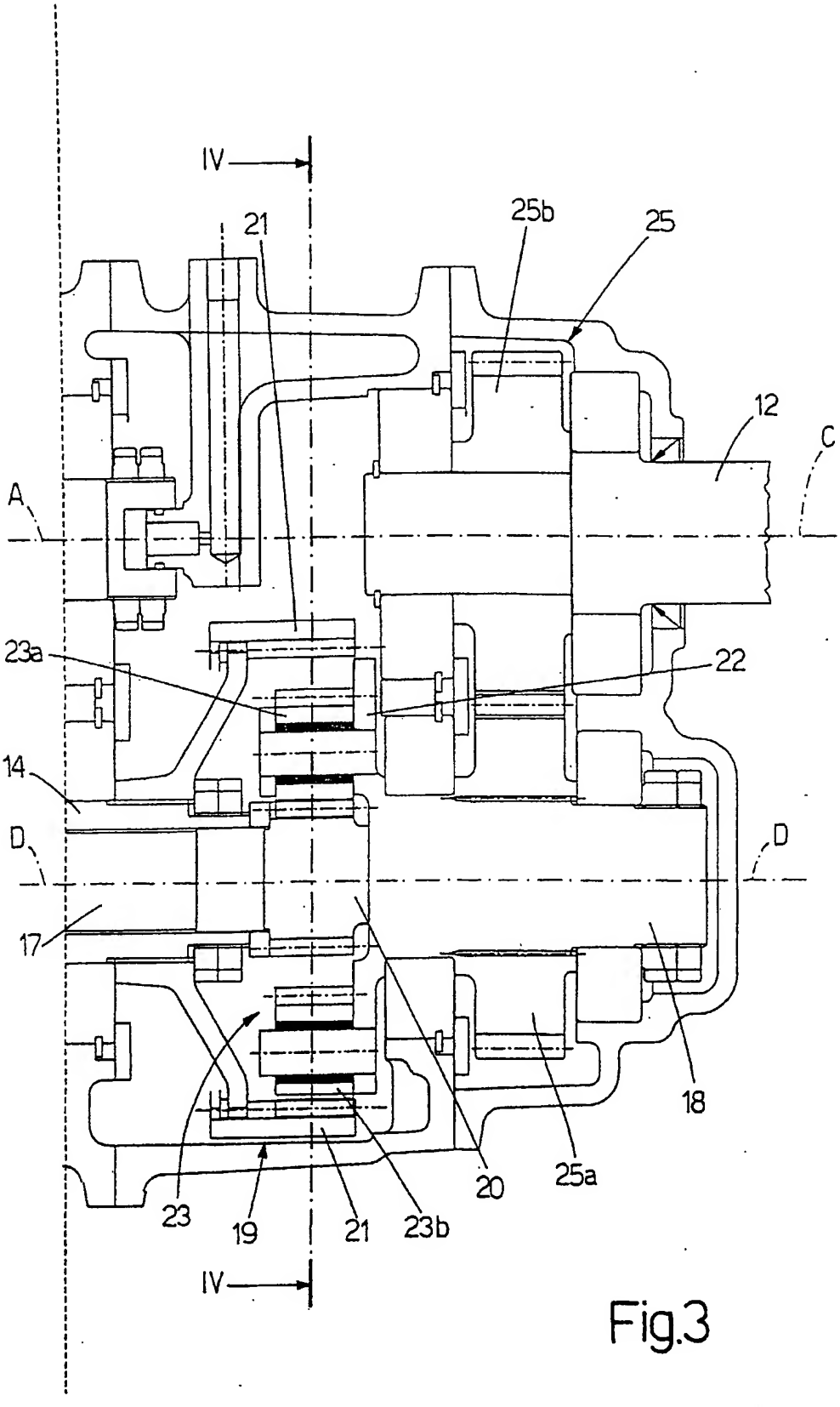

Fig.3

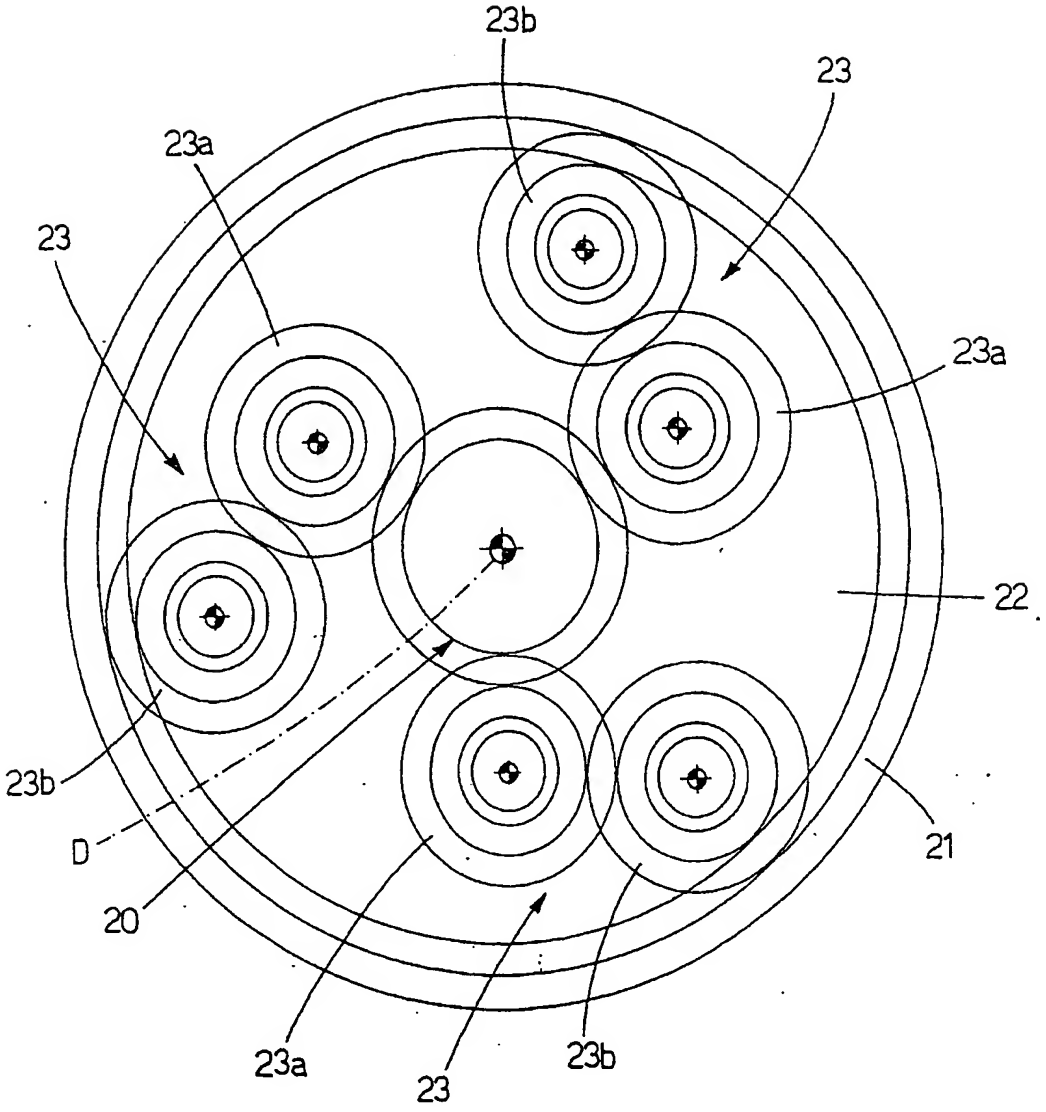

Fig.4

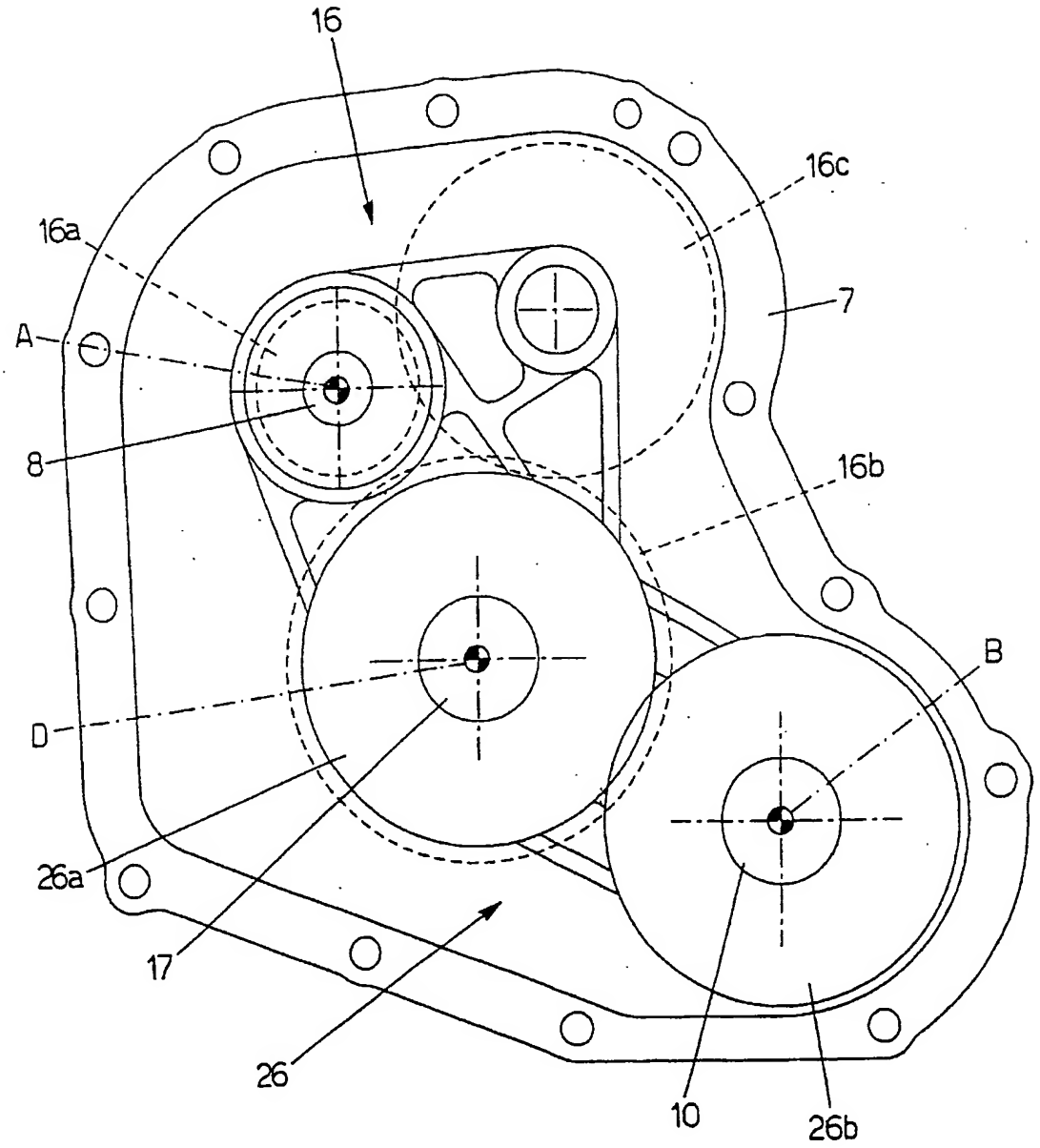

Fig.5

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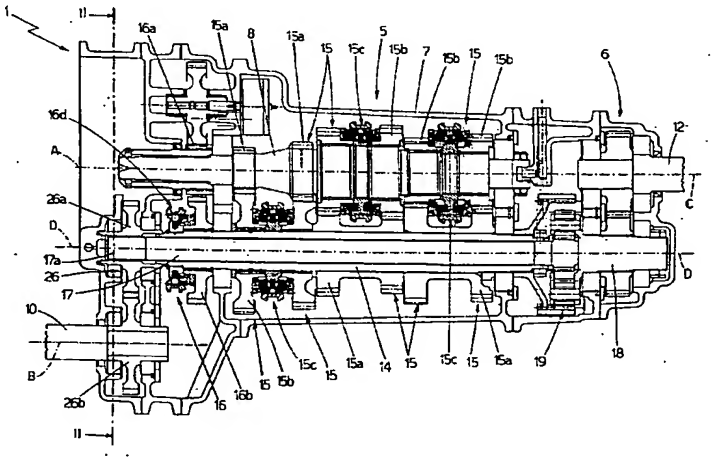

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16H B60K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 904 632 A (BROWN DAVID ET AL) 18 May 1999 (1999-05-18)	1-3,6-9
A	abstract column 2, line 46 -column 6, line 28; figures 1,2	4,5
Y	EP 1 120 587 A (FUJI HEAVY IND LTD) 1 August 2001 (2001-08-01) abstract column 5, line 14 - line 43; figure 1	1-3,6-9
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A	the whole document	4,5
A	EP 0 442 437 A (BREVINI SPA) 21 August 1991 (1991-08-21) column 2, line 27 - line 44; figures 2,3	4,5

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☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Topp, S

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